European Space Agency
Research and Science Support Department
Planetary Missions Division

Rosetta - MIRO

To Planetary Science Archive Interface Control Document

RO-MIR-IF-0001

Version 3.0

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Distribution List

Recipient	Organisation	Recipient

Change Log

Date	Sections Changed	Reasons for Change
2003-Aug-12	all	Initial version
2003-Sep-09	many	EDITS AS A RESULT OF PDS TELECON
2003-Nov	2,4	
2003-Dec	Changed doc.ID from UoB-IF-1234 to MIR-IF-0001. Updated keywords in 4.2 & App.1 per latest Archive Plan.	
2004-Jul	3-6	Corrections after review of sample label
2005-Dec	All	Revisions for delivery of groundtesting archive
2006-Nov	All	Revisions after PDS Internal Review and for delivery of calbrated data.
2006-Dec-11	Section 3.4.2l	Updated delivery dates and added items per email from Maud Barthelemy
2007-May-09	Sections 3.2.3 and 4.2 Section 5	Added documentation of coordinate systems used. Changed VOLUME keywords per revised Archive Conventions
2007-Oct-22	1.5, 2.3.4, 3.2.2, 3.4, 4.2, 6, 5	Added explanation of Times in data files, changes to labels and delivery contents, and revised structure files.
2008-Sep-02	Section 4.4 added, Section 7 revised	PDS review requested more documentation of data formats.
2009-May-15	6.4	Removed GMT field from Level-3 continuum files

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2012-Apr-30	6.1,6.2,6.3,6.4,6.5 6.5	Corrected MIRPOS codes (2=warm, 3=cold) Fixed typo in LDFRQ description.
2015-May-19	Many	Delivery of first post-hibernation data, utilizing Pipeline data generation software version 1.0.

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1 Introduction

1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to Planetary Science Archive Interface Control Document) is twofold. First it provides users of the MIRO instrument with detailed description of the products and a description of how they were generated, including data sources and destinations. Secondly, the EAICD describes the interface to the Planetary Science Archive (PSA) of ESA and is the official document between each experimenter team and the PSA.

1.2 Archiving Authorities

The Planetary Data System (PDS) Standard is used as archiving standard by

- NASA for U.S. planetary missions, implemented by PDS
- ESA for European planetary missions, implemented by the Research and Scientific Support Department (RSSD) of ESA

ESA's online Planetary Science Archive (PSA) was implemented

- to support and ease data ingestion
- to offer additional services to the scientific user community and science operations teams as e.g.
    - search queries that allow searches across instruments, missions and scientific disciplines
    - several data delivery options as
        - direct download of data products, linked files and data sets
        - ftp download of data products, linked files and data sets

The PSA aims for online ingestion of logical archive volumes and will offer the creation of physical archive volumes on request.

1.3 Contents

This document describes the data flow of the MIRO instrument on Rosetta from the s/c until the insertion into the PSA. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate the product are explained. Software that may be used to access the product is explained.

The design of the data set structure and the data product is given. Examples of these are given in the appendix.

1.4 Intended Readership

The MIRO science, software development and engineering team, the staff of the Planetary Science Archive design team, and any potential user of MIRO data.

1.5 Applicable Documents

AD1 Rosetta Archive Generation, Validation and Transfer Plan, 10 January 2006, RO-EST-PL-5011, Issue 2, Revision 3

AD2 Planetary Data System Standards Reference, 1 August 2003, Version 3.6, JPL D-7669, Part 2

AD3 Planetary Data System Data Dictionary Document, 28 August 2002, Revision E, JPL D-7116

AD4 MIRO Users Manual, RO-MIR-PR-0030, issue 5.1

AD5 Acton, C.H.; "Ancillary Data Services of NASA's Navigation and Ancillary Information Facility;" Planetary and Space Science, Vol. 44, No. 1, pp. 65-70, 1996.

AD6 Backus, C. and Gulkis, S., "CTS: Frequency Response as a Function of Temperature"

AD7 Rosetta Time Handling, 28 February 2006, RO-EST-TN-3165, Issue 1, Revision 1

1.6 Relationships to Other Interfaces

The controlling document of the interfaces discussed here is AD1. For further details on the MIRO instrument and its usage, see AD4.

1.7 Acronyms and Abbreviations

bps	bits per second
CCSDS	Consultative Committee for Space Data Systems
CODMAC	Committee on Data Management and Computation
CTS	Chirp Transform Spectrometer
DBMS	Database Management System
DDS	Data Distribution System (Darmstadt, Germany)
DVD	Digital Video Disk
ESA	European Space Agency
GHz	GigaHertz (10^9 Hz)
HSK	Housekeeping
IFP	Intermediate Frequency Processor
JPL	Jet Propulsion Laboratory (Pasadena, CA)
KHz	kiloHertz (10^3 Hz)
LO	Local Oscillator
MHz	MegaHertz (10^6 Hz)
MM	millimeter
MIRO	Microwave Instrument for the Rosetta Orbiter
NAIF	Navigation and Ancillary Information Facility
NASA	National Aeronautics and Space Agency (USA)
OBT	On-Board Time

PDS	Planetary Data System
PSA	Planetary Science Archive
rms	root mean square
SUBMM	submillimeter
TDB	Barycentric Dynamical Time
USO	Ultra Stable Oscillator
UTC	Coordinated Universal Time

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2 Overview of Process and Product Generation

2.1 MIRO Overview and Objectives

The MIRO investigation addresses the nature of the cometary nucleus, outgassing from the nucleus and development of the coma as strongly interrelated aspects of cometary physics, and searches for outgassing activity on asteroids. MIRO is configured both as a continuum and a very high spectral resolution line receiver. Center-band operating frequencies are near 188 GHz (1.6 mm) and 562 GHz (0.5 mm). Spatial resolution of the instrument at 562 GHz is approximately 50 m at a distance of 20 km from the nucleus; spectral resolution is sufficient to observe individual, thermally broadened, line shapes at all temperatures down to 10 K or less.

Four key volatile species - $H_2{}^{16}O$, CO, CH_3OH, and NH_3—including the oxygen isotopologues of water —$H_2{}^{17}O$ and $H_2{}^{18}O$—are pre-programmed for observation by the MIRO spectrometer, which only operates at submillimeter wavelengths. The primary retrieved products are abundance, velocity, and temperature of each species, along with their spatial and temporal variability. This information is used to infer coma structure and processes, including the nature of the nucleus/coma interface.

MIRO will sense the subsurface temperature of the nucleus to depths of several centimeters or more using the continuum channels at millimeter and submillimeter wavelengths. Model studies relate these measurements to electrical and thermal properties of the nucleus and address issues connected to the sublimation of ices, ice and dust mantle thickness, and the formation of gas and dust jets. The global nature of these measurements will allow in situ lander data to be extrapolated globally, while the long duration of the mission will allow us to follow the time variability of surface temperatures and gas production. MIRO is highly complementary to the IR mapping instrument on the orbiter (VIRTIS), having similar spatial resolution but greater depth penetration.

2.2 Instrument Description Summary

The MIRO instrument will provide both very sensitive continuum capability for temperature determination and extremely high-resolution spectroscopy for observation of molecular species. The instrument consists of two heterodyne radiometers, one at millimeter wavelengths (1.6 mm) and one at submillimeter wavelengths (0.5 mm). The millimeter and the submillmeter radiometers have continuum bandwidths of 0.5 GHz and 1.0 GHz respectively in addition, the submillimeter receiver has a total spectroscopic bandwidth of 180 MHz and a spectral resolution of 44 kHz. In the spectroscopic mode, 4096 channels, each having a bandwidth of 44 kHz, are observed simultaneously.

The performance parameters that govern the MIRO instrument design include system sensitivity, spatial resolution, radiometric accuracy (both absolute and relative), beam pattern and pointing accuracy, together with the mass, power, volume envelope, and environmental conditions available within the spacecraft. The MIRO instrument performance characteristics are summarised in Table 2.2. More detailed information can be found in the MIRO User Manual (AD4).

Equipment	**Property**	**Millimeter-Wave**	**Submillimeter-Wave**
Telescope	Primary Diameter Primary F/D Sidelobes Spatial Resolution Footprint size (at 2 km)	30 cm 1 –30 dB 23.8 arcmin ~15 m	30 cm 1 –30 dB 7.5 arcmin ~5 m
Spectral Performance	Frequency Band 1st IF Bandwidth 1st IF Frequency Range Spectral Resolution Allocated Spectral Range per line Accuracy	188.5–191.5 GHz 550 MHz 1–1.5 GHz n/a n/a n/a	547.5–580.5 Ghz 11 GHz 5.5-16.5 GHz 44 kHz nominally 20 MHz 10 kHz
Spectrometer	Center Frequency/Bandwidth Number of channels	n/a n/a	1350/180 MHz 4096
Radiometric Performance	DSB Receiver Noise Temperature SSB Spectroscopic Sensitivity (300 KHz, 2 min) : relative absolute Continuum Sensitivity (1 sec): relative absolute	~2000K n/a n/a 1 K rms 3 K rms	~4000 K 2 K rms 3 K rms 1 K rms 3 K rms
Data Rates	Instantaneous Rate Continuum Mode Spectroscopic Mode On-board Storage	 <1 kbps 2.5 kbps 0.2 GB (one day's data volume, Mode 3, 100% duty cycle)	

Table 2.2. MIRO Instrument Performance Characteristics

2.3 Data Products Description

2.3.1 Introduction

The MIRO instrument has 6 major modes of operation and data-taking that reflect operational combinations of its two continuum radiometers and the spectrometer: engineering mode, millimeter continuum mode, submillimeter continuum mode, dual continuum mode, CTS/submillimeter continuum mode, and CTS/dual continuum mode. In addition, a special mode has been designed for planetary and asteroid flybys. A number of data compression options are obtained in each mode by varying the data-taking rate (integration time per sample) and/or spectral resolution of the radiometers and spectrometer. The specific parameters for each mode are described in more detail in the MIRO User Manual (AD4), Volume 6.1, and are summarized here.

All data files that will be delivered to the PSA are table files, consisting of time sequences of measured data. This applies to engineering (housekeeping), continuum and spectroscopic data, both raw and calibrated. (The detailed structure of these files is defined by the Structure Files listed in Appendix 2.) It is anticipated that, in the future, derived products will be generated in image, cube or map format, but these formats have not yet been defined.

2.3.2 Major Data Modes

Engineering Mode

In engineering mode the MIRO software is collecting engineering data from 56 internal sensors. The sampling of these sensors is at a 5 Hz rate. All engineering measurements are 12-bit A/D converted values. The engineering mode telemetry is sent to the spacecraft in the form of a housekeeping telemetry packet. One engineering telemetry packet is typically generated every 11 seconds.

Millimeter Continuum Mode

In millimeter continuum mode continuum data are collected from the millimeter radiometer at a 20 Hz. rate. All continuum data consist of 16-bit values. The millimeter continuum data are nominally packetized into science telemetry packets every 10 seconds. A ‘summing value’ parameter can cause the MIRO software to sum either 1, 2, 5, 10 or 20 separate continuum values prior to putting them into the telemetry packet. This feature can reduce the data rate to as little as one millimeter continuum packet every 200 seconds.

Submillimeter Continuum Mode

Sub-millimeter continuum mode is identical to the millimeter continuum mode in data collection and packing except that a different set of electronics is powered on. Millimeter and submillimeter continuum data are contained in separate science telemetry packets, identified by a field in the source data header.

Dual Continuum Mode

In dual continuum mode the millimeter and submillimeter continuum are collected simultaneously. When running in dual continuum mode, the summing value parameter mentioned earlier is applied to both sets of data, causing equal amounts of millimeter and submillimeter data to be generated.

CTS / Submillimeter Continuum Mode

This mode adds the collection of chirp transform spectrometer (CTS) data. The CTS is programmed by the MIRO software to run for an initial sub-integration period of approximately 5 seconds. An internal LO frequency generator is then switched, which has the effect of introducing a small shift in the frequencies, and another 5 second period is observed. These pairs of observations are repeated with the respective results being summed over time. Selectable integration periods are 30, 60, 90 and 120 seconds. The data from the two LO frequencies are then subtracted from each other to provide a single 4096-element difference spectrum.

The 4096 data values can be further reduced by application of a smoothing function whereby data from several channels are combined and weighted to produce fewer final channels. Smoothing window sizes are 1, 5, 7 and 9 channels. A mask is applied to the CTS data and only 12 bits of each resulting measurement are returned.

CTS data collection and the LO frequency switching is coordinated with the collection of continuum data. Exactly 100 continuum samples are taken during each CTS scan. Upon receipt of the data on the ground it is known at which LO frequency all of the continuum measurements were made.

If the CTS has just been powered on, an internal calibration of the CTS is performed. This consists of loading the 4 CTS sum of square tables with a linear ramping pattern. A 10,000 cycle integration is then performed and the resulting data read out. The data are then averaged to yield the mid-point of the table. The resulting mid-point values for each table are downlinked in telemetry packets for monitoring over time.

CTS / Dual Continuum Mode

This is the same as the CTS / SMM continuum mode except that the millimeter data are also collected.

Asteroid Mode

This special data-taking mode has been implemented for the asteroid and planetary encounters to enable MIRO to follow the rapid Doppler shift of spectral lines that may be visible. The primary characteristic of this mode is that LO frequency switching is turned off. The LO is set to either +5 MHz or - 5 MHz from the nominal frequency prior to the encounter. At the specified encounter time, the LO frequency is switched ± 5 Mhz (opposite from the first setting) from the nominal frequency. Continuum data are collected at 20 Hz. Each set of CTS data consists of a single 5-second integration with all 32 bits returned for each 4096 channels. This mode is not applied during the comet observations.

2.3.3 Calibration and Test Data

2.3.3.1 Thermal-Vacuum Ground Tests

These tests were carried out at JPL from 15 May to 29 June 2001 and were intended to determine characteristics of the MIRO instrument in vacuum conditions and as a function of temperature. The emphasis was on deriving parameters that cannot be obtained under ambient conditions, such as the noise figures of various electronic components, the frequency response of the instrument and the linearity of the response, and the stability of several features. The data obtained from these tests and the accompanying log files are delivered as the first MIRO archive dataset.

2.3.3.2 Radiometric Calibration

The MIRO instrument is calibrated on a periodic basis and immediately following every mode change. An automatic calibration will take place every 1895 seconds, if not interrupted by a mode change command, which triggers a calibration immediately. The normal interval of 1895 seconds allows 95 seconds for the calibration and 1800 seconds (30 minutes) for the data collection period. The 1800 seconds allows for complete integration periods of 30, 60, 90, and 120 seconds (60, 30, 20, and 15 integrations respectively).

The 95 seconds of calibration data are distributed as follows:

Time (seconds)	Activity
5	3 mirror movements/no data collection
30	Warm load position- CTS + continuum + engineering
30	Cold load position - CTS + continuum + engineering
30	Sky position - CTS + continuum + engineering

These calibration data are included in the level-2 data files as part of the time sequence. They are flagged by a Calibration field in the header columns (see the Structure files in Appendix 2).

Receiver gains (in counts per Kelvin) are computed by measuring the difference in the number of counts from the receiver as the input is switched between loads at two different (known) temperatures. Load temperature differences (in counts) are obtained by switching between warm load and cold load. Data records are converted to temperature units by dividing by the number of counts per Kelvin. The temperature units reported are Rayleigh-Jeans temperature units, where the product kTB (k = Boltzmann's constant, B = bandwidth and T is the Rayleigh-Jeans temperature) is the received power. A factor of two multiplies the spectroscopic record to convert it to an equivalent single sideband temperature. Fluctuations in the gains resulting from LO switching cause small offsets visible in the differenced spectroscopic data, which will be corrected for in future work. These errors are of the order of 5K, about 0.1% of the system temperatures.

2.3.3.3 Frequency calibration

The frequency calibration of the CTS is a complex subject, described in AD6, which is included in this delivery as the file MIRO_CTS_FREQUENCY_CALIBRATION_V0 in the Document directory. The Receiver Frequency of the radiation entering the instrument (in the range 547.5 – 580.5 GHz, see Table 2.2) is translated by a series of mixers in the IFP to the frequency range of the CTS, centered at 1350 MHz. The relationship between IFP output frequency and channel number is a function of temperature. In the calibrated data in this delivery, the SPECT_T1 field (see Appendix 2, Section 6.2) gives this temperature, which is always 67.9 C in this dataset, since that is the standard value to which the calibrated data have been rebinned.

2.3.4 Operational Scenarios

MIRO collected scientific and calibration data prior to the landing phase, which was described in previous archive deliveries.

Normal mode of operation – In the normal mode of operation, the MIRO instrument operates in a frequency switching mode. If the instrument is in a continuum only mode, the frequency switching is turned off.

Asteroid mode – A special data-taking mode, called the "Asteroid Mode", was implemented for the asteroid and planetary encounters, and was not use during the mission phases contained in this delivery.

This delivery includes data from the post-hibernation re-commisioning and check-out of MIRO (27-29 April 2014), and science data collected during comet approach through the lander phase (9 May 2014 to 19 November 2014). Early in this period the spacecraft was power-constrained, requiring MIRO to be switched off much of the time. By August 2014, however, power levels were such that MIRO could be on continuously. Numerous observing sequences were utilized in the current delivery to optimize science return given various operational constraints. It is beyond the scope of this document to describe the sequences in detail, but in general they include long stares at the center of the nucleus, scans over portions of the nucleus (which may or may not include parts of the surrounding coma), scans over the entire nucleus (which may or may not include significant parts of the coma), stares or scans in parts of the coma, and scans over large regions of the coma.

2.3.5 Data Flows

The MIRO telemetry packets coming from the spacecraft are retrieved from the ESOC Data Distribution System (DDS) at Darmstadt by PI-controlled workstations located at the Jet Propulsion Laboratory in Pasadena, CA, under the direct responsibility of the PI. The telemetry records are written in their original SFDU formats for permanent safekeeping in the MIRO archival system at JPL. These telemetry records will be kept in the MIRO project but are not considered part of the formal science archive. The Data Archive has the following characteristics:

1) The MIRO Data Archive system is located at JPL in Pasadena, CA.
2) The Data Archive system has the capability to store and maintain all the data coming from ESA (instrument/science data, housekeeping data, auxiliary data, navigation data, command logs) in their original format (SFDU format where applicable).
3) The Data Archive system is capable of transferring data to the MIRO data base management system (DBMS) for further processing.
4) The Data Archive system has the capability to store and maintain all the data in PDS format that will be delivered to the Small Bodies Node of the PDS.

All data (science, housekeeping and auxiliary) in the MIRO Raw Data Archive at JPL are capable of being ingested into the MIRO DBMS. This DBMS is the means of access to the data for team members doing science analysis of these data.

Delivery of data to the Rosetta Mission Archive of the PSA of ESA and the Small Bodies Node of the PDS of NASA is done by extracting data from the MIRO DBMS into file formats defined by this document and generating PDS labels for these files. These files are placed in directory trees in the MIRO Data Archive, along with all associated documentation and index tables. Compressed copies of these directories are delivered to the PSA and PDS for external archival and will also remain online in the MIRO Data Archive. The MIRO team will support the peer reviews of MIRO-related data that are conducted by the ESA-PDS archiving team and will correct or otherwise appropriately resolve any liens identified by the peer review(s).

The Small Bodies Node of PDS will work jointly with the archiving scientists at ESA to prepare the complete ROSETTA archive within ESA consistent with all PDS standards (see AD2). The ROSETTA archive resides both at ESA and with NASA's PDS. PDS and the ESA archiving scientists will carry out the peer review of all data to ensure that outside users can make good scientific use of the data from the archive. The final archive will be maintained electronically both by the PDS Small Bodies Node and by ESA. ESA will prepare CD ROM (or successor media such as DVD ROM) copies of the archive for distribution both through ESA and through PDS.

The raw data at JPL will receive a preliminary radiometric calibration. Further data reduction and data analysis will be carried out to provide calibrated data in standard formats and derived products such as maps of abundances or column densities. Co-Is will also have electronic access to the data from the database in Pasadena. Co-Is will also produce selected calibrated data sets and return them to the Pasadena database.

The MIRO science team will also produce, at the home institutions of the team members, derived products as appropriate. These might include spatial maps, rectified to a common coordinate system, of the abundances of specific molecules.

The MIRO team expects that the ROSETTA project may wish to combine data from MIRO with data from other instruments, particularly ALICE, OSIRIS or VIRTIS, on a single archive volume. This will considerably enhance the usability of the archive for scientific correlative analysis. Archive preparation of any such combination of data sets from different instruments will be the responsibility either of IDSs carrying out comparative studies or of the ROSETTA project within ESA.

3 Archive Format and Content

3.1 Format

This section describes the format of the MIRO Instrument Team Archive volumes. Data in the archive will be formatted in accordance with Planetary Data System specifications (AD2).

3.1.1 Volume Format

This document will not be concerned with any particular media formats such as DVD's because data will be delivered electronically. When applicable, media formats will be determined by the PDS. Also, for present purposes, datasets will be regarded as equivalent to volumes.

3.1.2 Data Set Naming

The informal Dataset Names used in this document are formed by appending the mission phase descriptor to the instrument name. Examples are:

MIRO_THERMALVAC
MIRO_COMMISSIONING
MIRO_EARTH1

The formal PDS values for DATA_SET_NAME and DATA_SET_ID are formed according to the rules defined in AD1:

DATA_SET_NAME = "ROSETTA-ORBITER <target name> MIRO <processing level> <mission phase> <description> <version>".
Examples are:

"ROSETTA-ORBITER CAL MIRO 2 GRND THERMAL-VAC V1.0"
"ROSETTA-ORBITER EARTH MIRO 2 EAR1 Earth-1 V1.0"

DATA_SET_ID = "RO-<target ID>-MIRO-<processing level>-<mission phase>-<description>-<version>".
Examples are:

"RO-CAL-MIRO-2-GRND-THERMALVAC-V1.0"
"RO-E-MIRO-2-EAR1-EARTH1-V1.0"

See further AD1 for allowed values for these items.

3.1.3 File Name Formats

The following scheme will be used for names of files containing data products:

MIRO_<level>_<detector>_begindatetime.<ext>

The level field is the CODMAC processing level.

Valid names for the detector field include:

MM
SUBMM
CTS
HSK

File extensions can be at least:

DAT binary data
TXT acsii data, lines of variable length, delimited typically with <CR>
LBL ascii detached label file
DOC text description where necessary

Datetime format will be yyyydddhhmmss, where ddd is 1-based Julian day, i.e. Jan 1 is day 1.

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

The MIRO Data Products comply with the Planetary Data System standards for file formats and labels, as specified in the PDS Standards Reference (AD2).

3.2.2 Time Standards

The MIRO Data Products are intended to comply with the CCSDS Time Code Format Standard (CCSDS 301.0-B-2).

The On-Board Time (OBT) of the Rosetta spacecraft is used in the PDS keywords SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT. The format of this time (as defined in RO-EST-TN-3165, Rosetta Time Handling) is:
"i/mmmmmmmmm[.nnnnn]"
where:
i = integer signifying which zero point is in use. (Currently, all OBTs have i=1, signifying that the zero point is at 2003-01-01T00:00:00 UTC. This integer will change if the clock is ever reset, which is not planned but may happen as a result of unforeseen circumstances.)
mmmmmmmmm = integer seconds since the zero point.
nnnnn = (optional) fractional seconds in units of 1/65536 sec.
Therefore, the floating-point time since the zero point represented by a given OBT is:
time = mmmmmmmmm + nnnnn/65536.

The OBT is not used internally in any MIRO data files. Instead, table entries are marked by Sun Modified Julian Time (SMJT) or "unix time", which is elapsed seconds since 1970-01-01T00:00:00 UTC. This takes leapseconds into account and is therefore in the UTC system. The conversion from SMJT to Ephemeris Time (ET2000), which is the standard TDB time system used by NAIF, is given by:

$$ET2000 = SMJT - 946727958.816 + LEAPSECS + O(0.0017)$$

Where the last term represents a sinusoidal correction for the Earth's motion that never exceeds

0.0017 seconds, and LEAPSECS is the number of leapseconds that have been added between 1970 and the relevant date. At the time of writing, LEAPSECS = 24. A Fortran-77 program, named UTCCON, that converts between SMJT and the ISO standard UTC representation, is provided in the DOCUMENT directory. See AD7 for further discussion and conversions to other time systems.

3.3 Data Validation

General data validation procedures are described in the MIRO User Manual (AD4). No data validation has been performed on these products, beyond basic checks on the completeness of Continuum packets and CTS spectra. Validation done on higher-level products will be described in the delivery documentation.

3.4 Content

This section describes the directories and contents of the MIRO Data Product volumes, including the file names, file contents, file types, and organization responsible for providing the files. The data described herein appear on each volume of the MIRO Data Product volume series.

3.4.1 Volume Set

Since the Rosetta Project plans for electronic delivery and there is no need to bundle several datasets into one volume set, as a general rule, a volume shall be a dataset.

3.4.2 Data Set

The following table shows data set name (informal), DATA_SET_ID, delivery date, size, and data types contained, for each volume of the MIRO Data Product volume series through May 2015, as of the current writing. The naming follows section 3.1.2.

Dataset name and DATA_SET_ID	Delivery Date	Size (Mbytes)	Description
MIRO_Thermalvac RO-CAL-MIRO-2-GRND-THERMALVAC-V1.0	Nov 2006	763	Science Files, Engineering Files
MIRO_Commissioning (raw) RO-X-MIRO-2-CVP-COMMISSIONING-V1.0 .	Nov 2006	300	Science Files, Engineering Files
MIRO_Commissioning (calibrated) RO-X-MIRO-3-CVP-COMMISSIONING-V1.0	Nov 2006	325	Science Files, Geometry Files
MIRO_Earth1 (raw) RO-E-MIRO-2-EAR1-EARTH1-V1.0	Nov 2006	185	Science Files, Engineering Files
MIRO_Earth1 (calibrated) RO-E-MIRO-3-EAR1-EARTH1-V1.0	Nov 2006	197	Science Files, Geometry Files
MIRO_Tempel1 (raw) RO-C-MIRO-2-CR2-9P-TEMPEL1-V1.0	Dec 2006	660	Science Files, Engineering Files
MIRO_Tempel1 (calibrated)	Dec 2006	765	Science Files, Geometry Files

RO-C-MIRO-3-CR2-9P-TEMPEL1-V1.0

MIRO_Earth2 (raw) RO-E-MIRO-2-EAR2-EARTH2-V1.0	Jun 2008	58	Science Files, Engineering Files,
MIRO_Earth2 (calibrated) RO-E-MIRO-3-EAR2-EARTH2-V1.0	Jun 2008	55	Science Files, Geometry Files
MIRO_Steins (raw) RO-A-MIRO-2-AST1-STEINS-V1.0	Jul 2009	54	Science Files, Engineering Files,
MIRO_Steins (calibrated) RO-A-MIRO-3-AST1-STEINS-V1.0	Jul 2009	47	Science Files, Geometry Files,
MIRO_Earth3 (raw) RO-E-MIRO-2-EAR3-EARTH3-V1.0	Nov 2010	150	Science Files, Engineering Files,
MIRO_Earth3 (calibrated) RO-E-MIRO-3-EAR3-EARTH3-V1.0	Nov 2010	170	Science Files, Geometry Files
MIRO_Lutetia (raw) RO-A-MIRO-2-AST2-LUTETIA-V1.0	Mar 2011	300	Science Files, Engineering Files
MIRO_Lutetia (calibrated) RO-A-MIRO-3-AST2-LUTETIA-V1.0	Mar 2011	420	Science Files, Geometry Files
MIRO_Prelanding (raw) RO-C-MIRO-2-PRL-67P-V1.0	May 2015	8,000	Science Files, Engineering Files
MIRO_Prelanding (calibrated) RO-C-MIRO-3-PRL-67P-V1.0	May 2015	8,000	Science Files, Geometry Files

3.4.3 Directories

This section describes the contents of each directory in a Data Product dataset.

3.4.3.1 Root Directory

The following table lists the files located in the root directory.

File Name	File Contents
AAREADME.TXT	Introductory information about the contents and format of the volume.
CALIBRATION	Directory containing MIRO calibration data.
CATALOG	Directory containing catalog files: mission, instrument, and dataset Descriptions which are duplicated in the PDS higher-level catalog.

DATA	Root directory for each data type present in this volume: Science (Spectroscopic and Continum) and Engineering.
DOCUMENT	Directory containing basic documentation.
ERRATA.TXT	Cumulative listing of comments and corrections.
GEOMETRY	Directory containing information about spacecraft and target positions and instrument attitude,
INDEX	Directory containing index tables for the data files in this volume.
LABEL	Directory containing structure files references by PDS labels.
SOFTWARE	Directory containing software to manipulate and display MIRO data.
VOLDESC.CAT	Description of the contents of this volume in a PDS-labelled format.

Appendix 1 contains a listing of the VOLDESC.CAT file for the first dataset listed in 3.4.2.

3.4.3.2 Calibration Directory

This directory is to contain the calibration files used to convert level 2 products to level 3. Since the MIRO calibration data are part of the normal telemetry stream and are included in the files in the DATA directoriy, at this time no separate calibration files exist. Therefore, this directory is omitted for both level-2 and level-3 archives in the current deliveries.

3.4.3.3 Catalog Directory

This directory contains files providing a top-level descirption of the Rosetta mission and spacecraft, the MIRO instrument and its team, and its data products.

The following table describes the files in the Catalog Directory.

File Name	File Contents
CATINFO.TXT	A description of the contents of this directory.
MISSION.CAT	PDS mission catalog information about the Rosetta.
TARGET.CAT .	PDS catalog information about the target bodies observed by Rosetta.
INSTHOST.CAT	PDS instrument catalog information about the Rosetta Spacecraft.
INST.CAT	PDS instrument catalog information about the MIRO instrument.
PERSONNEL.CAT	PDS personnel catalog information about the MIRO Team members responsible for generating the data products.
REF.CAT	PDS references mentioned in other files.

SOFTWARE.CAT	PDS catalog information about software included in this archive (currently empty).
DATASET.CAT	PDS data set catalog information about the MIRO Data Product data sets.

3.4.3.4 Data Directory

This directory contains three sub-directories, Spectroscopic, Continuum, and Engineering, which each contain all the data files for the corresponding data type in the data set.

3.4.3.4.1 Continuum Data Directory

This directory contains science data files containing Continuum (MM and SMM) data, and their detached labels.

3.4.3.4.2 Engineering Data Directory

This directory contains files containing Engineering data, and their detached labels.

3.4.3.4.3 Spectroscopic Data Directory

This directory contains science data files containing Spectroscopic (CTS) data, and their detached labels.

3.4.3.5 Index Directory

This directory contains index files providing summary information for all the data products in this data set.

The following table describes the files in the Index Directory.

File Name	File Contents
INDEX.LBL	A volume index file.
INDEXINFO.TXT	A description of the contents of this directory.
SPECINDX.TAB	Index table file for all Spectroscopic data products.
SPECINDX.LBL	Detached label file describing the contents of specindx.tab.
CONTINDX.TAB	Index table file for all Continuum data products.
CONTINDX.LBL	Detached label file describing the contents of contindx.tab.
ENGINDX.TAB	Index table file for all Engineering data products.
ENGINDX.LBL	Detached label file describing the contents of engindx.tab.
GEOMINDX.TAB	Index table file for all Geometry files (not present if data set includes no Geometry files).

GEOMINDX.LBL Detached label file describing the contents of geomindx.tab files (not present if data set includes no Geometry files).

3.4.3.6 Label Directory

This directory includes files referenced by data files on this volume, e.g. FMT files containing header descriptions. Sample structure files used in MIRO PDS labels are given in Appendix 2.

3.4.3.7 Document Directory

This directory contains various files documenting the contents of this data set.

The following table describes the files in the Document Directory.

File Name	File Contents
DOCINFO.TXT	A description of the contents of this directory.
MIRO_READ_DATA.ASC	A Fortran-77 program to list selected parts of MIRO data files, intended primarily as additional documentation for the structure files in Appendix 2.
UTCCON.ASC	A Fortran-77 program that converts between the time system used in the data files and standard UTC notation.

Other documents, as appropriate. E.g., in the Groundtesting delivery, log files of the tests are included.

3.4.3.9 Software Directory

It is intended that the software used to calibrate the data will be included in this directory for level-3 products. Currently, this software is in an early stage of development and is tied to the local database used by the processing, hence is not suitable for delivery to the archive at this time. The description of the algorithms in section 2.3.3.2 fulfills this function, for now. Therefore, this directory was omitted in the current deliveries.

3.4.4 Data and Label Files

Science and Engineering data files are placed in the appropriate subdirectories of the data directory (3.4.3.4), together with their detached labels. Other data files shall be placed in their appropriate directories, all with detached PDS label.

4. Detailed Interface Specifications

In this chapter, detailed information about the archive design at instrument and detector level is given.

4.1 Data Product Identification

The basic MIRO data product is a binary file containing scientific or ancillary data in table format, and an associated detached label file in PDS format describing the data. The filenaming convention for these files is given in 3.1.3.

A data file contains a continuous stream of data for one of the MIRO instruments (CTS, MM radiometer, or SUBMM radiometer) or for Engineering, see section 2.3. Note that the Data Mode in which the data were taken (section 2.3.2) is not relevant to the type of the data product, although the mode information for each row of the table is stored in the file. The length of a data file is arbitrary, being defined by the process of obtaining the data from the database, but it shall not exceed an observing time of one week

4.2 PDS Label Structure, Definition and Format

The following keywords are used in the PDS labels for MIRO data products (with the values given when these will be invariant):

PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES
FILE_RECORDS
^TABLE
DATA_SET_NAME
DATA_SET_ID
MISSION_NAME = “INTERNATIONAL ROSETTA MISSION”
MISSION_ID = ROSETTA
INSTRUMENT_HOST_NAME = “ROSETTA ORBITER”
INSTRUMENT_HOST_ID = RO
INSTRUMENT_NAME = “MICROWAVE INSTRUMENT FOR THE ROSETTA ORBITER”
INSTRUMENT_ID = MIRO
INSTRUMENT_TYPE = {“RADIOMETER”,”SPECTROMETER”}
^INSTRUMENT_DESCRIPTION = “RO-MIR-IF-0001_16.TXT”
INSTRUMENT_MODE_ID
INSTRUMENT_MODE_DESC
TARGET_NAME
TARGET_TYPE
MISSION_PHASE_NAME
ORBIT_NUMBER
SPACECRAFT_CLOCK_START_COUNT
SPACECRAFT_CLOCK_STOP_COUNT
START_TIME
STOP_TIME
SC_SUN_POSITION_VECTOR
SC_TARGET_POSITION_VECTOR

```
SC_TARGET_VELOCITY_VECTOR
SUB_SPACECRAFT_LATITUDE
SUB_SPACECRAFT_LONGITUDE
SPACECRAFT_ALTITUDE
NOTE = "
        The values of the keywords SC_SUN_POSITION_VECTOR,
        SC_TARGET_POSITION_VECTOR and SC_TARGET_VELOCITY_VECTOR
        are related to the ECLIPJ2000 reference frame.
        The values of SUB_SPACECRAFT_LATITUDE and SUB_SPACECRAFT_LONGITUDE
        are northren latitude and eastern longitude in the standard
        planetocentric IAU <TARGET_BODY> frame.
        All values are computed for the time 20xx-xx-xxTxx:xx:xx.xxx,
        the midpoint of the observations.
        Distances are given in <km>, velocities in <km/s>, angles in <deg>."
PRODUCT_CREATION_TIME
PRODUCT_ID
PRODUCT_TYPE PROCESSING_LEVEL_ID
PRODUCER_FULL_NAME = "Dr. Samuel Gulkis"
PRODUCER_INSTITUTION_NAME = "JET PROPULSION LABORATORY"
PRODUCER_ID = JPL
DATA_QUALITY_ID
DATA_QUALITY_DESC = "1 = nominal, 2 = problematical"
OBJECT = TABLE
 INTERCHANGE_FORMAT = BINARY
 COLUMNS
 ROWS
 ROW_BYTES
 ^STRUCTURE = "xxxx.FMT"
END_ OBJECT = TABLE
END
```

The FMT file pointed to by the ^STRUCTURE keyword will be one of the five files in Appendix 2 (see 3.4.3.6). These contain the detailed specification of the contents of the data.

The file pointed to by the ^INSTRUMENT_DESCRIPTION resides in the Document directory (3.4.3.7).

No mission-specific keywords will be used. All keywords are defined in the PDS data dictionary (AD3 or online at http://pds.nasa.gov/tools/data_dictionary_lookup.cfm).

The coordinate system used for the geometric items in the label (SC...VECTOR) ia the J2000 system, which is an inertial cartesian frame based on the Earth mean equator of Epoch J2000.

4.3 Overview of Detectors

4.3.1 Spectrometer data

The contents of the spectrometer (CTS) level-2 and level-3 data products are fully defined by the structure files CTS_LEVEL_2_FORMAT.FMT, listed in Appendix 6.1, and CTS_LEVEL_3_FORMAT.FMT, listed in Appendix 6.2.

Sample record printouts generated by the program MIRO_READ_DATA found in the DOCUMENT directory are also shown in those appendices.

For further details, see MIRO User Manual (AD4) 6.2.3.

4.3.2 Radiometer (continuum) data

The contents of the mm and submm radiometer level-2 and level-3 data products are fully defined by the structure files CONT_LEVEL_2_FORMAT.FMT, listed in Appendix 6.3 and CONT_LEVEL_3_FORMAT.FMT, listed in Appendix 6.4.

Sample record printouts generated by the program MIRO_READ_DATA found in the DOCUMENT directory are also shown in those appendices.

For further details, see MIRO User Manual (AD4) 6.2.4 and 6.2.5.

4.3.3 Engineering data

The contents of the Engineering data products are fully defined by the structure file ENG_LEVEL_2_FORMAT.FMT, listed in Appendix 6.5.

A sample record printout generated by the program MIRO_READ_DATA found in the DOCUMENT directory is also shown in that appendix.

For further details, see MIRO User Manual (AD4) 6.2.2.

4.4 Data Format Description

The contents of the MIRO data files are fully defined by the *.FMT files in the LABEL directories of the archives. Here, a brief explanation is provided of the science-data portion of CTS and Continuum files. (The Engineering files are not discussed further as they are not likely to be of interest to the general user.)

It is important to understand that the Data colum of the MIRO science files contains a large data array in each row. In the CTS files, this contains a complete spectrum, whereas in the Continuum files this is a packet of data in time order. The name of the Data column is SPECTRAL_DATA in the CTS files, but simply D in the Continuum files.

The layout of a MIRO science file can be viewed as a 2-D array with N rows (where N is the value of the FILE_RECORDS keyword in the label), each row containing M entries, with a "header" on the left-hand side, consisting of the columns preceding the Data column of the table).

For Level-3 CTS files: M = 4250 spectral items and the header contains 19 items;

for Level-2 CTS files: M = 4096 spectral items and the header contains 10 items, one of which is itself an array of 24 items;

for Level-3 Continuum files: M = 200 data items and the header contains 13 items;

for Level-2 Continuum files: M = 200 data items and the header contains 12 items.

When program MIRO_READ_DATA (see Section 3.4.3.7) is used in the "formatted output" mode, it prints, for each row, one entry each for the header columns and then four entries for the Data column, starting with the "starting data item #" that the program prompts for. (Four was picked for the number of entries arbitrarily, just to give a representative sample.) When the program is run in "average spectrum" mode, then it prints all entries of the Data column to a file, averaged over the rows specified. This allows the user to save these data for purposes of plotting or analyisis. (The averaging feature is most useful for the CTS data, while for Continuum data single packets are more meaningful.)

A very important item is the Cal/No-cal flag in Column 6. When this flag is 0, then the spectrum is for a calibration sequence, and the data are brightness temperatures; furthermore, the targets are either sky, cold load or warm load, depending on the value of the Mirror position flag in column 2. However, when the Cal/No-cal flag is 1, then the data are difference spectra between the two LO states, so will be close to zero on average. Only the Cal=1 data (and the Sky data for Cal=0) are the observational data for the target body. (It is unfortunate that Cal=0 means calibration, but this is a historical accident and cannot now be changed.)

See Appendix 3 (Section 7) for a description of an IDL-based tool to read MIRO data that is provided by PDS, called READPDS.

Frequency calibration: the total bandwidth of MIRO is 180 MHz, with the frequency going inversely with the bin (channel) number of the CTS spectra, in an approximately linear fashion. The exact dependence is dependent on the temperature, which is why the number of bins are increased from 4096 for the raw data to 4250 for the calibrated data. This is described in the document CTS_FREQUENCY_CALIBRATION.PDF in the DOCUMENT directories of the Level-3 archives. This also describes how the true frequencies of the lines observed (which span 33 GHz, far more than the nominal bandwidth) are mapped into the CTS spectrum. Discontinuities between the eight regions of the different mappings appear as smooth transitions, because of the design of the CTS. Data in the transition regions between these bands are not usable.

5. Appendix 1: VOLDESC.CAT

```
PDS_VERSION_ID  = PDS3
RECORD_TYPE     = "STREAM"
RECORD_BYTES    = "UNK"

OBJECT     = VOLUME
  VOLUME_SERIES_NAME          = " ROSETTA SCIENCE ARCHIVE"
  VOLUME_SET_NAME             = " ROSETTA: MIRO DATA"
  VOLUME_SET_ID               = " USA_NASA_JPL_ROMIR_1000"
  VOLUMES                     = 1
  VOLUME_NAME                 = " RAW MIRO DATA FOR THE GROUND PHASE"
  VOLUME_ID                   = " ROMIR_1001”
  VOLUME_VERSION_ID           = " VERSION 1"
  VOLUME_FORMAT               = " ISO-9660"
  DATA_SET_ID                 = "RO-CAL-MIRO-2-GRND-THERMALVAC-V1.0"
  MEDIUM_TYPE                 = "ELECTRONIC"
  PUBLICATION_DATE            = 2006-11-06
  DESCRIPTION                 = "This volume is the first containing
    Microwave Instrument for the Rosetta Orbiter (MIRO) data.  It
    contains data obtained during ground testing at NASA/JPL."

  OBJECT     = DATA_PRODUCER
    INSTITUTION_NAME  = "JET PROPULSION LABORATORY"
    FACILITY_NAME     = "MIRO DATA PROCESSING TEAM"
    FULL_NAME         = "SAMUEL GULKIS"
    ADDRESS_TEXT      = "JET PROPULSION LABORATORY \N
      4800 OAK GROVE DRIVE \n
      MAILSTOP 183-301 \n
      PASADENA, CA 91109 \n
      USA"
  END_OBJECT  = DATA_PRODUCER

  OBJECT     = CATALOG
    ^MISSION_CATALOG            = "MISSION.CAT"
    ^INSTRUMENT_HOST_CATALOG    = "INSTHOST.CAT"
    ^INSTRUMENT_CATALOG         = "INST.CAT"
    ^DATA_SET_CATALOG           = "DATASET.CAT"
    ^REFERENCE_CATALOG          = "REF.CAT"
    ^PERSONNEL_CATALOG          = "PERSONNEL.CAT"
    ^SOFTWARE_CATALOG           = "SOFTWARE.CAT"
    ^TARGET_CATALOG             = "TARGET.CAT"
END_OBJECT  = CATALOG

END_OBJECT  = VOLUME

END
```

6. Appendix 2: Structure Files

6.1 Spectrometer Level 2 Data (see section 4.3.1)

Filename: CTS_LEVEL_2_FORMAT.FMT
Rosetta/miro cts raw data structure

This structure label gives the data structure for the data decommutated from the telemetry for the uncalibrated (raw) data from the MIRO Chirp Transform Spectrometer (CTS).

```
OBJECT       = COLUMN
 NAME        = TIME
 COLUMN_NUMBER  = 1
 DATA_TYPE    = IEEE_REAL
 FORMAT       = F16.5
 START_BYTE  = 1
 BYTES       = 8
 DESCRIPTION = "Time of acquisition of the spectrum in elapsed UTC seconds
                after 1-Jan-1970 (see EAICD Section 3.2.2)."
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = MIRPOS
 COLUMN_NUMBER  = 2
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE  = 9
 BYTES       = 1
 DESCRIPTION = "Mirror position: 1: sky, 2: warm target, 3: cold target"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = POWERMODE
 COLUMN_NUMBER  = 3
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE   = 10
 BYTES       = 1
 DESCRIPTION = "Values 1-6 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = INTEGRATION
 COLUMN_NUMBER  = 4
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE  = 11
```

```
 BYTES        = 1
 DESCRIPTION = "Values 0-3 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = SMOOTHING
 COLUMN_NUMBER  = 5
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE  = 12
 BYTES        = 1
 DESCRIPTION = "Values 0-3 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = CAL
 COLUMN_NUMBER  = 6
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE  = 13
 BYTES        = 1
 DESCRIPTION = "0: Calibration in progress, 1: No calibration in progress""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = LO
 COLUMN_NUMBER  = 7
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE  = 14
 BYTES        = 1
 DESCRIPTION = "LO designation, 0 or 1"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = NUMPLL
 COLUMN_NUMBER  = 8
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I2
 START_BYTE  = 15
 BYTES        = 1
 DESCRIPTION = "Number of used pll (phased-lock-loop) bytes"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
  NAME        = PLL_DATA
  COLUMN_NUMBER  = 9
  DATA_TYPE   = MSB_UNSIGNED_INTEGER
 FORMAT        = 24I1
  START_BYTE = 16
  BYTES       = 24
```

```
 ITEMS       = 24
 ITEM_BYTES  = 1
 DESCRIPTION          = "pll (phased-lock-loop) status bytes as described in MIRO User Manual
6.2.3."
END_OBJECT   = COLUMN

OBJECT      = COLUMN
 NAME       = ASTEROID
 COLUMN_NUMBER  = 10
 DATA_TYPE   = MSB_UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE = 40
 BYTES      = 1
 DESCRIPTION          = "Asteroid mode: 0: in asteroid mode, 1: not in asteroid mode, 4 as described
                      In MIRO User Manual 6.1.2.2."
 END_OBJECT= COLUMN

OBJECT      = COLUMN
 NAME       = SPECTRAL_DATA
 COLUMN_NUMBER  = 11
 DATA_TYPE   = MSB_INTEGER
 FORMAT        = 4096I9
 START_BYTE = 41
 BYTES      = 16384
 ITEMS      = 4096
 ITEM_BYTES  = 4
 DESCRIPTION          = "Uncalibrated brightness temperature as signed integer"
END_OBJECT   = COLUMN
```

The following is an example of the first record of a Level-2 Spectroscopic file, with just 4 of the 4250 data fields shown, in both hex and formatted representations:

```
Listing of rows     1 to     1 for file RO-E-MIRO-2-EAR1-EARTH1-
V1.0/DATA/SPECTROSCOPIC/MIRO_2_CTS_20050630809.DAT

 COL.#:          1         2  3  4  5  6  7  8  9
                        10    11
 ITEMS:  41D08A0D4F32378B 02 01 00 00 00 00 06 80 80 80 80 80 80 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00974000 009A8000 0097C000 009B4000

COL.#:          1          2    3    4    5    6    7    8    9
                                                         10      11
 ITEMS:   1.109931325E+09   2   1   0   0   0   0   6 128 128 128 128 128 128   0   0   0   0
  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     9912320    10125312
9945088    10174464
```

6.2 Spectrometer Level 3 Data (see section 4.3.1)

Filename: CTS_LEVEL_3_FORMAT.FMT
Rosetta/miro cts calibrated data structure

This structure label gives the data structure for the calibrated data from the MIRO Chirp Transform Spectrometer (CTS).

```
OBJECT      = COLUMN
 NAME        = TIME
 COLUMN_NUMBER  = 1
 DATA_TYPE    = IEEE_REAL
 FORMAT     = F16.5
 UNIT        = SECOND
 START_BYTE  = 1
 BYTES       = 8
 DESCRIPTION = "Time of acquisition of the spectrum in elapsed UTC seconds
                after 1-Jan-1970 (see EAICD Section 3.2.2)."
END_OBJECT   = COLUMN

OBJECT      = COLUMN
 NAME        = UTC
 COLUMN_NUMBER  = 2
 DATA_TYPE    = TIME
 FORMAT     = A19
 START_BYTE  = 9
 BYTES       = 19
 DESCRIPTION = "Absolute time of acquisition of the spectrum in the UTC system."
END_OBJECT   = COLUMN

OBJECT      = COLUMN
 NAME        = MIRPOS
 COLUMN_NUMBER  = 3
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE  = 28
 BYTES       = 1
 DESCRIPTION = "Mirror position: 1: sky, 2: warm target, 3: cold target"
END_OBJECT   = COLUMN

OBJECT      = COLUMN
 NAME        = POWERMODE
 COLUMN_NUMBER  = 4
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE   = 29
 BYTES       = 1
 DESCRIPTION = "Values 1-6 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT      = COLUMN
 NAME        = INTEGRATION
 COLUMN_NUMBER  = 5
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE  = 30
```

```
 BYTES       = 1
 DESCRIPTION = "Values 1-3 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = SMOOTHING
 COLUMN_NUMBER  = 6
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE  = 31
 BYTES       = 1
 DESCRIPTION = "Values 1-4 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = CAL
 COLUMN_NUMBER  = 7
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE  = 32
 BYTES       = 1
 DESCRIPTION = "0: Calibration in progress, 1: No calibration in progress""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = LO
 COLUMN_NUMBER  = 8
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT       = I1
 START_BYTE  = 33
 BYTES       = 1
 DESCRIPTION = "LO designation, 0 or 1"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
  NAME       = ASTEROID
  COLUMN_NUMBER  = 9
  DATA_TYPE   = MSB_UNSIGNED_INTEGER
  FORMAT       = I1
  START_BYTE = 34
  BYTES      = 1
  DESCRIPTION  = "Asteroid mode: 0: in asteroid mode, 1: not in asteroid mode."
  END_OBJECT= COLUMN

OBJECT       = COLUMN
 NAME        = SPECT_T1
 COLUMN_NUMBER  = 10
 DATA_TYPE    = IEEE_REAL
 FORMAT       = F6.2
 START_BYTE  = 35
 BYTES       = 4
```

```
 DESCRIPTION  = "Engineering temperature of CTS (degrees C)"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
  NAME         = TYPE
  COLUMN_NUMBER  = 11
  DATA_TYPE    = CHARACTER
  FORMAT        = A1
  START_BYTE = 39
  BYTES       = 1
  DESCRIPTION  = "Type of calibration data used: C = cold, S = sky"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = STATUS
 COLUMN_NUMBER  = 12
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE  = 40
 BYTES       = 1
 DESCRIPTION  = "Status flag:  0 = nominal, <0 = problematical, >0 = TBD"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
  NAME         = METHOD
  COLUMN_NUMBER  = 13
  DATA_TYPE    = CHARACTER
  FORMAT        = A1
  START_BYTE = 41
  BYTES       = 1
  DESCRIPTION  = "Method of calibration: A = average, I = interpolate, N = nearest neighbor"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = PLL
 COLUMN_NUMBER  = 14
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I4
 START_BYTE  = 42
 BYTES       = 1
 DESCRIPTION = "Logical OR of the PLL bytes in the raw record, indicating phased-lock loop status"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = RA
 COLUMN_NUMBER  = 15
 DATA_TYPE    = IEEE_REAL
 FORMAT        = F7.3
 UNIT          = DEGREE
 START_BYTE  = 43
 BYTES       = 4
```

```
 DESCRIPTION = "Right Ascension of the MIRO boresight"
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME        = DEC
 COLUMN_NUMBER  = 16
 DATA_TYPE    = IEEE_REAL
 FORMAT        = F7.3
 UNIT          = DEGREE
 START_BYTE  = 28
 BYTES        = 4
 DESCRIPTION = "Declination of the MIRO boresight"
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME        = VEL
 COLUMN_NUMBER  = 17
 DATA_TYPE    = IEEE_REAL
 FORMAT        = E11.3
 UNIT          = KILOMETER_PER_SECOND
 START_BYTE  = 51
 BYTES        = 4
 DESCRIPTION = "Relative velocity"
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME        =  S0
 COLUMN_NUMBER  = 18
 DATA_TYPE    = IEEE_REAL
 FORMAT        = E11.3
 START_BYTE  = 55
 BYTES        = 4
 DESCRIPTION = "Spare"
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME        =  S1
 COLUMN_NUMBER  = 19
 DATA_TYPE    = IEEE_REAL
 FORMAT        = E11.3
 START_BYTE  = 59
 BYTES        = 4
 DESCRIPTION = "Spare"
END_OBJECT  = COLUMN

OBJECT      = COLUMN
  NAME        = SPECTRAL_DATA
  COLUMN_NUMBER  = 20
  DATA_TYPE   = IEEE_REAL
  FORMAT        = 4250F6.0
  UNIT             = KELVIN
```

```
  START_BYTE = 63
  BYTES      = 17000
  ITEMS      = 4250
  ITEM_BYTES  = "Antenna temperatures"
END_OBJECT  = COLUMN
```

The following is an example of the first record of a Level-3 Spectroscopic file, with just 4 of the 4250 data fields shown, in both hex and formatted representations:

```
Listing of rows     1 to     1 for file RO-E-MIRO-3-EAR1-EARTH1-
V1.0/DATA/SPECTROSCOPIC/MIRO_3_CTS_20050631015.DAT

 COL.#:          1                 2         3  4  5  6  7  8  9     10   11 12 13 14     15
     16       17       18       19       20
 ITEMS:  41D08A0D4F32378B 2005-03-04T10:15:25 02 01 00 00 00 00 00 4287CCCD 53 30 4E 80
00000000 00000000 00000000 00000000 00000000 467EDF40 4685B133 46879D24 468A3874

 COL.#:          1                 2          3   4   5   6   7   8   9     10    11  12 13 14
     15         16         17         18         19         20
 ITEMS:   1.109931325E+09 2005-03-04T10:15:25   2   1   0   0   0   0   0  6.790E+01 S  48 N
128  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  1.631E+04  1.711E+04  1.736E+04
1.769E+04
```

6.3 Continuum Level 2 Data (see section 4.3.2)

Filename: CONT_LEVEL_2_FORMAT.FMT
Rosetta/MIRO continuum files raw data structure

This structure label gives the data structure for the data decommutated from the telemetry for the uncalibrated (raw) data from the MIRO Millimeter and Submillimeter Continuum Radiometers.

```
OBJECT      = COLUMN
  NAME       = TIME
  COLUMN_NUMBER  = 1
  DATA_TYPE   = IEEE_REAL
  FORMAT        = F16.5
  START_BYTE = 1
  BYTES      = 8
  DESCRIPTION  = "Time of start of acquisition of the data in elapsed UTC seconds
                  after 1-Jan-1970 (see EAICD Section 3.2.2)."
 END_OBJECT  = COLUMN

OBJECT      = COLUMN
  NAME       = TIME1
  COLUMN_NUMBER  = 2
  DATA_TYPE   = IEEE_REAL
  FORMAT        = F16.5
  START_BYTE = 9
  BYTES      = 8
  DESCRIPTION  = "Time of acquisition of the 100th element of the raw data array, if summation=1, or
                   of the 50th element if summation=2 or greater;  this is zero if summation=0."
```

```
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = TIME2
 COLUMN_NUMBER  = 3
 DATA_TYPE   = IEEE_REAL
 FORMAT         = F16.5
 START_BYTE = 17
 BYTES       = 8
 DESCRIPTION  = "Time of acquisition of the 100th element of the raw data array, if summation=2 or
                 greater; otherwise zero."
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = TIME3
 COLUMN_NUMBER  = 4
 DATA_TYPE   = IEEE_REAL
 FORMAT         = F16.5
 START_BYTE = 25
 BYTES       = 8
 DESCRIPTION  = "Time of acquisition of the 150th element of the raw data array, if summation=2 or
                 greater; otherwise zero."
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = MIRPOS
 COLUMN_NUMBER  = 5
 DATA_TYPE   = MSB_UNSIGNED_INTEGER
 FORMAT         = I1
 START_BYTE = 33
 BYTES       = 1
 DESCRIPTION          = "Mirror position: 1: sky, 2: warm target, 3: cold target"
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = POWERMODE
 COLUMN_NUMBER  = 6
 DATA_TYPE   = MSB_UNSIGNED_INTEGER
 FORMAT         = I1
 START_BYTE = 34
 BYTES       = 1
 DESCRIPTION          = "Values 1-6 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME        = SUMMATION
 COLUMN_NUMBER  = 7
 DATA_TYPE   = MSB_UNSIGNED_INTEGER
 FORMAT         = I1
 START_BYTE = 35
 BYTES       = 1
```

```
 DESCRIPTION          = "Values 0-4 as described in MIRO User Manual 6.1.2.1""
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME       = ND
 COLUMN_NUMBER  = 8
 DATA_TYPE   = MSB_UNSIGNED_INTEGER
 FORMAT         = I3
 START_BYTE = 36
 BYTES      = 1
 DESCRIPTION          = "Number of elements in raw data array;  should always be 200."
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME       = MMSUBTRACTION
 COLUMN_NUMBER  = 9
 DATA_TYPE   = UNSIGNED_INTEGER
 FORMAT         = I5
 START_BYTE = 37
 BYTES      = 2
 DESCRIPTION = "Offset in millimeter continuum data, as described in MIRO User Manual 6.2.5."
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME       = SMMSUBTRACTION
 COLUMN_NUMBER  = 10
 DATA_TYPE   = UNSIGNED_INTEGER
 FORMAT         = I5
 START_BYTE = 39
 BYTES      = 2
 DESCRIPTION = "Offset in submillimeter continuum data, as described in MIRO User Manual 6.2.4."
END_OBJECT   = COLUMN

OBJECT      = COLUMN
 NAME        = CALMODE
 COLUMN_NUMBER  = 11
 DATA_TYPE   = UNSIGNED_INTEGER
 FORMAT         = I1
 START_BYTE = 41
 BYTES      = 2
 DESCRIPTION          = "0: Calibration in progress, 1: No calibration in progress"
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME       = SP
 COLUMN_NUMBER  = 12
 DATA_TYPE   = UNSIGNED_INTEGER
 FORMAT         = I1
 START_BYTE = 43
 BYTES      = 2
 DESCRIPTION          = "Spare, not used"
```

```
END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME       = D
 COLUMN_NUMBER  = 13
 DATA_TYPE = MSB_INTEGER
 FORMAT         = 200I6
 START_BYTE = 45
 BYTES      = 400
 ITEMS      = 200
 ITEM_BYTES  = 2
 DESCRIPTION          = "Uncalibrated brightness temperature as signed integer"
END_OBJECT  = COLUMN
```

The following is an example of the first record of a Level-2 Continuum file, with just the first 4 of the 200 data fields shown, in both hex and formatted representations:

```
Listing of rows     1 to     1 for file RO-E-MIRO-2-EAR1-EARTH1-
V1.0/DATA/CONTINUUM/MIRO_2_MM_20050630809.DAT

 COL.#:          1                2                3                4         5   6   7   8   9
 10   11   12   13
 ITEMS:  41D08A0D4F339485 41D08A0D508AF41F 0000000000000000 0000000000000000 02 01 00 C8 0000
0000 0000 0000 1CA9 1CAB 1CAB 1CAA

COL.#:          1               2               3               4          5   6   7   8
9  10  11  12   13
 ITEMS:   1.109931325E+09  1.109931330E+09  0.000000000E+00  0.000000000E+00   2   1   0 200
 0   0   0   0  7337  7339  7339  7338
```

6.4 Continuum Level 3 Data (see section 4.3.2)

Filename: CONT_LEVEL_3_FORMAT.FMT
Rosetta/MIRO continuum files raw data structure

This structure label gives the data structure for the calibrated data from the MIRO Millimeter and Submillimeter Continuum Radiometers.

```
OBJECT      = COLUMN
 NAME       = TIME
 COLUMN_NUMBER  = 1
 DATA_TYPE   = IEEE_REAL
 FORMAT         = F16.5
 START_BYTE = 1
 BYTES      = 8
 DESCRIPTION  = "Time of start of acquisition of the data in elapsed UTC seconds
                 after 1-Jan-1970 (see EAICD Section 3.2.2)."
 END_OBJECT  = COLUMN

OBJECT      = COLUMN
 NAME       = TIME1
 COLUMN_NUMBER  = 2
```

```
  DATA_TYPE   = IEEE_REAL
  FORMAT         = F16.5
  START_BYTE = 9
  BYTES      = 8
  DESCRIPTION  = "Time of acquisition of the 100th element of the raw data array, if summation=1, or
                  of the 50th element if summation=2 or greater;  this is zero if summation=0."
 END_OBJECT  = COLUMN

OBJECT      = COLUMN
  NAME       = TIME2
  COLUMN_NUMBER  = 3
  DATA_TYPE   = IEEE_REAL
  FORMAT         = F16.5
  START_BYTE = 17
  BYTES      = 8
  DESCRIPTION  = "Time of acquisition of the 100th element of the raw data array, if summation=2 or
                  greater; otherwise zero."
 END_OBJECT   = COLUMN

OBJECT      = COLUMN
  NAME       = TIME3
  COLUMN_NUMBER  = 4
  DATA_TYPE   = IEEE_REAL
  FORMAT         = F16.5
  START_BYTE = 25
  BYTES      = 8
  DESCRIPTION  = "Time of acquisition of the 150th element of the raw data array, if summation=2 or
                  greater; otherwise zero."
 END_OBJECT   = COLUMN

OBJECT      = COLUMN
  NAME       = UTC
  COLUMN_NUMBER  = 5
  DATA_TYPE   = TIME
  FORMAT         = A19
  START_BYTE = 33
  BYTES      = 19
  DESCRIPTION  = "Absolute time of start of acquisition of the data in the UTC system."
END_OBJECT   = COLUMN

OBJECT      = COLUMN
  NAME       = MIRPOS
  COLUMN_NUMBER  = 6
  DATA_TYPE   = MSB_UNSIGNED_INTEGER
  FORMAT         = I1
  START_BYTE = 52
  BYTES      = 1
  DESCRIPTION           = "Mirror position: 1: sky, 2: warm target, 3: cold target"
END_OBJECT   = COLUMN

OBJECT      = COLUMN
```

```
 NAME         = POWERMODE
 COLUMN_NUMBER  = 7
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE = 53
 BYTES      = 1
 DESCRIPTION          = "Values 1-6 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = SUMMATION
 COLUMN_NUMBER  = 8
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE = 54
 BYTES      = 1
 DESCRIPTION          = "Values 0-4 as described in MIRO User Manual 6.1.2.1""
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = ND
 COLUMN_NUMBER  = 9
 DATA_TYPE    = MSB_UNSIGNED_INTEGER
 FORMAT        = I3
 START_BYTE = 55
 BYTES      = 1
 DESCRIPTION          = "Number of elements in raw data array;  should always be 200."
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = MMSUBTRACTION
 COLUMN_NUMBER  = 10
 DATA_TYPE    = UNSIGNED_INTEGER
 FORMAT        = I5
 START_BYTE = 56
 BYTES      = 2
 DESCRIPTION  = "Offset in millimeter continuum data, as described in MIRO User Manual 6.2.5."
END_OBJECT   = COLUMN

OBJECT       = COLUMN
 NAME         = SMMSUBTRACTION
 COLUMN_NUMBER  = 11
 DATA_TYPE    = UNSIGNED_INTEGER
 FORMAT        = I1
 START_BYTE = 58
 BYTES      = 2
 DESCRIPTION  = "Offset in submillimeter continuum data, as described in MIRO User Manual 6.2.4."
END_OBJECT    = COLUMN

OBJECT       = COLUMN
 NAME          = CALMODE
```

```
  COLUMN_NUMBER  = 12
  DATA_TYPE   = UNSIGNED_INTEGER
  FORMAT        = I1
  START_BYTE = 60
  BYTES      = 2
  DESCRIPTION          = "0: Calibration in progress, 1: No calibration in progress"
END_OBJECT   = COLUMN

OBJECT      = COLUMN
  NAME       = SP
  COLUMN_NUMBER  = 13
  DATA_TYPE   = UNSIGNED_INTEGER
  FORMAT        = I1
  START_BYTE = 62
  BYTES      = 2
  DESCRIPTION          = "Spare, not used"
END_OBJECT   = COLUMN

OBJECT      = COLUMN
  NAME       = D
  COLUMN_NUMBER  = 14
  DATA_TYPE  = IEEE_REAL
  FORMAT        = 200F6.0
  UNIT        = KELVIN
  START_BYTE = 64
  BYTES      = 800
  ITEMS       = 200
  ITEM_BYTES  = 4
  DESCRIPTION          = "Antenna temperatures"
END_OBJECT   = COLUMN
```

The following is an example of the first record of a Level-3 Continuum file, with just the first 4 of the 200 data fields shown, in both hex and formatted representations:

```
Listing of rows     1 to     1 for file RO-E-MIRO-3-EAR1-EARTH1-
V1.0/DATA/CONTINUUM/MIRO_3_MM_20050631017.DAT

 COL.#:          1                2                3                4                 5
  6  7  8  9  10   11   12   13     14
 ITEMS:  41D08A0D6A110EAA 41D08A0D6B6223E2 0000000000000000 0000000000000000 2005-03-
04T10:17:12 01 01 00 C8 0000 0000 0001 0000 412CBA5D 4135BD7F 4135BD7F 413BBF95

 COL.#:          1                2                3                4                 5
   6   7    8   9  10  11  12  13      14
 ITEMS:   1.109931432E+09  1.109931438E+09  0.000000000E+00  0.000000000E+00 2005-03-
04T10:17:12   1   1   0 200   0   0   1   0  1.080E+01  1.136E+01  1.136E+01  1.173E+01
```

6.5 Housekeeping Data (see section 4.3.3)

Filename: ENG_LEVEL_2_FORMAT.FMT
Rosetta/MIRO engineering raw data structure

This structure label gives the data structure for the data decommutated from the telemetry for the engineering (housekeeping) data from the MIRO instrument.
*/

```
OBJECT                 = COLUMN
 NAME                  = TIME
 COLUMN_NUMBER  = 1
 DATA_TYPE             = IEEE_REAL
 FORMAT            = F16.5
 START_BYTE            = 1
 BYTES          = 8
 DESCRIPTION = "Time of acquisition of the data packet in elapsed UTC
                seconds after 1-Jan-1970 (see EAICD Section 3.2.2)."
END_OBJECT  = COLUMN

OBJECT                 = COLUMN
 NAME                  = SPECT_T1
 COLUMN_NUMBER  = 2
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F7.3
 START_BYTE            = 9
 BYTES          = 4
 DESCRIPTION = "CTS Temperature sensor #1 Branch A (deg C)"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
 NAME                  = SPECT_T2
 COLUMN_NUMBER  = 3
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F7.3
 START_BYTE            = 13
 BYTES          = 4
 DESCRIPTION = "CTS Temperature sensor #2 Branch A (deg C)"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
 NAME                  = SPECT_T3
 COLUMN_NUMBER  = 4
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F7.3
 START_BYTE            = 17
 BYTES          = 4
 DESCRIPTION = "CTS Temperature sensor #1 Branch B (deg C)"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
 NAME                  = SPECT_T4
 COLUMN_NUMBER  = 5
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F7.3
```

```
 START_BYTE           = 21
 BYTES          = 4
 DESCRIPTION = "CTS Temperature sensor #2 Branch B (deg C)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = SPECT_T5
 COLUMN_NUMBER  = 6
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F7.3
 START_BYTE           = 25
 BYTES          = 4
 DESCRIPTION = "CTS Temperature sensor #1 analog tray (deg C)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = SPECT_T6
 COLUMN_NUMBER  = 7
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F7.3
 START_BYTE           = 29
 BYTES          = 4
 DESCRIPTION = "CTS Temperature sensor #2 analog tray (deg C)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = EU_TEMP
 COLUMN_NUMBER  = 8
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F7.3
 START_BYTE           = 33
 BYTES          = 4
 DESCRIPTION = "Electronics Unit (EU) temperature (deg C)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = ECAL_TEMP
 COLUMN_NUMBER  = 9
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F5.0
 START_BYTE           = 37
 BYTES          = 4
 DESCRIPTION = "Reference temperature (634 Ohms) (Digital Units)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = POS_5V_EU
 COLUMN_NUMBER  = 10
 DATA_TYPE             = IEEE_REAL
 FORMAT               = F5.3
 START_BYTE           = 41
```

```
 BYTES          = 4
 DESCRIPTION = "EU +5V voltage monitor (V)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = POS_12V_EU
 COLUMN_NUMBER  = 11
 DATA_TYPE              = IEEE_REAL
 FORMAT                = F6.3
 START_BYTE             = 45
 BYTES          = 4
 DESCRIPTION = "EU +12V voltage monitor (V)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = NEG_12V_EU
 COLUMN_NUMBER  = 12
 DATA_TYPE              = IEEE_REAL
 FORMAT                = F7.3
 START_BYTE             = 49
 BYTES          = 4
 DESCRIPTION = "EU -12V voltage monitor (V)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = 3V_EU
 COLUMN_NUMBER  = 13
 DATA_TYPE              = IEEE_REAL
 FORMAT                = F5.3
 START_BYTE             = 53
 BYTES          = 4
 DESCRIPTION = "EU +3.3V voltage monitor (V)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = POS_24V_EU
 COLUMN_NUMBER  = 14
 DATA_TYPE              = IEEE_REAL
 FORMAT                = F6.3
 START_BYTE             = 57
 BYTES          = 4
 DESCRIPTION = "EU +24V voltage monitor (V)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = POS_5V_ANA_EU
 COLUMN_NUMBER  = 15
 DATA_TYPE              = IEEE_REAL
 FORMAT                = F5.3
 START_BYTE             = 61
 BYTES          = 4
```

```
 DESCRIPTION = "EU +5V analog voltage monitor (V)"
END_OBJECT = COLUMN

OBJECT = COLUMN
 NAME = POS_5V_CURR_EU
 COLUMN_NUMBER = 16
 DATA_TYPE = IEEE_REAL
 FORMAT = E11.3
 START_BYTE = 65
 BYTES = 4
 DESCRIPTION = "EU +5V current monitor (A)"
END_OBJECT = COLUMN

OBJECT = COLUMN
 NAME = POS_12V_CURR_EU
 COLUMN_NUMBER = 17
 DATA_TYPE = IEEE_REAL
 FORMAT = E11.3
 START_BYTE = 69
 BYTES = 4
 DESCRIPTION = "EU +12V current monitor (A)"
END_OBJECT = COLUMN

OBJECT = COLUMN
 NAME = NEG_12V_CURR_EU
 COLUMN_NUMBER = 18
 DATA_TYPE = IEEE_REAL
 FORMAT = E11.3
 START_BYTE = 73
 BYTES = 4
 DESCRIPTION = "EU -12V current monitor (A)"
END_OBJECT = COLUMN

OBJECT = COLUMN
 NAME = POS_24V_ANA_CURR_EU
 FORMAT = E11.3
 COLUMN_NUMBER = 19
 DATA_TYPE = IEEE_REAL
 START_BYTE = 77
 BYTES = 4
 DESCRIPTION = "EU +24V current monitor (A)"
END_OBJECT = COLUMN

OBJECT = COLUMN
 NAME = 3V_CURR_EU
 COLUMN_NUMBER = 20
 DATA_TYPE = IEEE_REAL
 FORMAT = E11.3
 START_BYTE = 81
 BYTES = 4
 DESCRIPTION = "EU +3V current monitor (A)"
```

```
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = POS_5V_ANA_CURR_EU
 COLUMN_NUMBER  = 21
 DATA_TYPE             = IEEE_REAL
 FORMAT               = E11.3
 START_BYTE            = 85
 BYTES          = 4
 DESCRIPTION = "EU +5V analog current monitor (A)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = TLM_Heating
 COLUMN_NUMBER  = 22
 DATA_TYPE             = IEEE_REAL
 FORMAT               = E11.3
 START_BYTE            = 89
 BYTES          = 4
 DESCRIPTION = "this item has been removed, see MIRO User Manual 6.2.2.5.
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = TLM_RF
 COLUMN_NUMBER  = 23
 DATA_TYPE             = IEEE_REAL
 FORMAT               = E11.3
 START_BYTE            = 93
 BYTES          = 4
DESCRIPTION            = "this item has been removed, see MIRO User Manual 6.2.2.5.
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = CTS_V_ANA_1
 COLUMN_NUMBER  = 24
 DATA_TYPE             = IEEE_REAL
 FORMAT                = F5.3
 START_BYTE            = 97
 BYTES          = 4
 DESCRIPTION = "CTS PG1 Voltage (V)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
 NAME                  = CTS_V_ANA_2
 FORMAT                = F5.3
 COLUMN_NUMBER  = 25
 DATA_TYPE             = IEEE_REAL
 START_BYTE            = 101
 BYTES          = 4
 DESCRIPTION = "CTS PG1 Voltage (V)"
END_OBJECT             = COLUMN
```

```
OBJECT                = COLUMN
 NAME                 = COLD_LOAD1_TEMP
 COLUMN_NUMBER  = 26
 DATA_TYPE            = IEEE_REAL
 FORMAT               = F6.1
 START_BYTE           = 105
 BYTES          = 4
 DESCRIPTION = "Cold load temperature #1 (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = COLD_LOAD2_TEMP
 COLUMN_NUMBER  = 27
 DATA_TYPE            = IEEE_REAL
 FORMAT               = F6.1
 START_BYTE           = 109
 BYTES          = 4
 DESCRIPTION = "Cold load temperature #2 (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = WARM_LOAD1_TEMP
 COLUMN_NUMBER  = 28
 DATA_TYPE            = IEEE_REAL
 FORMAT               = F5.1
 START_BYTE           = 113
 BYTES          = 4
 DESCRIPTION = "Warm load temperature #1 (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = OB_TEMP
 COLUMN_NUMBER  = 29
 DATA_TYPE            = IEEE_REAL
 FORMAT               = F5.1
 START_BYTE           = 117
 BYTES          = 4
 DESCRIPTION = "Optical Bench temperature (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = TELESCOPE1_TEMP
 COLUMN_NUMBER  = 30
 DATA_TYPE            = IEEE_REAL
 FORMAT               = F6.1
 START_BYTE           = 121
 BYTES          = 4
 DESCRIPTION = "Telescope #1 temperature (deg C)"
END_OBJECT            = COLUMN
```

```
OBJECT                  = COLUMN
 NAME                   = TELESCOPE2_TEMP
 COLUMN_NUMBER  = 31
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = F6.1
 START_BYTE             = 125
 BYTES          = 4
 DESCRIPTION = "Telescope #2 temperature (deg C)"
END_OBJECT               = COLUMN

OBJECT                  = COLUMN
 NAME                   = PLL_TEMP
 COLUMN_NUMBER  = 32
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = F5.1
 START_BYTE             = 129
 BYTES          = 4
 DESCRIPTION = "Phase lock loop temerature (deg C)"
END_OBJECT               = COLUMN

OBJECT                  = COLUMN
 NAME                   = IFP_DET_TEMP
 COLUMN_NUMBER  = 33
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = F5.1
 START_BYTE             = 133
 BYTES          = 4
 DESCRIPTION = "smm IF processor detector temperature (deg C)"
END_OBJECT               = COLUMN

OBJECT                  = COLUMN
 NAME                   = IFP_AMP_TEMP
 FORMAT                 = F5.1
 COLUMN_NUMBER  = 34
 DATA_TYPE              = IEEE_REAL
 START_BYTE             = 137
 BYTES          = 4
 DESCRIPTION = "smm IF processor amplifier temperature (deg C)"
END_OBJECT               = COLUMN

OBJECT                  = COLUMN
 NAME                   = SMM_LO_GUNN
 COLUMN_NUMBER  = 35
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = F5.1
 START_BYTE             = 141
 BYTES          = 4
 DESCRIPTION = "smm LO Gunn temperature (deg C)"
END_OBJECT               = COLUMN

OBJECT                  = COLUMN
```

```
 NAME                = MM_LO_GUNN
 COLUMN_NUMBER  = 36
 DATA_TYPE           = IEEE_REAL
 FORMAT              = F5.1
 START_BYTE          = 145
 BYTES        = 4
 DESCRIPTION = "mm LO Gunn temperature (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                = MOTOR_TEMP
 COLUMN_NUMBER  = 37
 DATA_TYPE           = IEEE_REAL
 FORMAT              = F5.1
 START_BYTE          = 149
 BYTES        = 4
 DESCRIPTION = "Mirror motor temperature (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                = SEN_EL
 COLUMN_NUMBER  = 38
 DATA_TYPE           = IEEE_REAL
 FORMAT              = F5.1
 START_BYTE          = 153
 BYTES        = 4
 DESCRIPTION = "Sensor Electronics Unit (SBEU) temperature (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                = WARM_LOAD2_TEMP
 COLUMN_NUMBER  = 39
 DATA_TYPE           = IEEE_REAL
 FORMAT              = F5.1
 START_BYTE          = 157
 BYTES        = 4
 DESCRIPTION = "Warm load temperature #2 (deg C)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                = CAL_TEMP_LOW
 COLUMN_NUMBER  = 40
 DATA_TYPE           = IEEE_REAL
 FORMAT              = F3.0
 START_BYTE          = 161
 BYTES        = 4
 DESCRIPTION = "Reference temperature 191 Ohms (digital units)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                = CAL_TEMP_HIGH
```

```
 COLUMN_NUMBER  = 41
 DATA_TYPE            = IEEE_REAL
 FORMAT              = F4.0
 START_BYTE          = 165
 BYTES         = 4
 DESCRIPTION = "Reference temperature 681 Ohms (digital units)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = POS_5V_SBEU
 COLUMN_NUMBER  = 42
 DATA_TYPE            = IEEE_REAL
 FORMAT              = F5.3
 START_BYTE          = 169
 BYTES         = 4
 DESCRIPTION = "SBEU +5V voltage monitor (V)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = POS_12V_1_SBEU
 COLUMN_NUMBER  = 43
 DATA_TYPE            = IEEE_REAL
 FORMAT              = F6.3
 START_BYTE          = 173
 BYTES         = 4
 DESCRIPTION = "SBEU +12V voltage monitor #1 (V)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = POS_12V_2_SBEU
 COLUMN_NUMBER  = 44
 DATA_TYPE            = IEEE_REAL
 FORMAT              = F6.3
 START_BYTE          = 177
 BYTES         = 4
 DESCRIPTION = "SBEU +12V voltage monitor #2 (V)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = NEG_12V_SBEU
 COLUMN_NUMBER  = 45
 DATA_TYPE            = IEEE_REAL
 FORMAT              = E11.3
 START_BYTE          = 181
 BYTES         = 4
 DESCRIPTION = "SBEU -12V voltage monitor (V)"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
 NAME                 = POS_5V_CURR_SBEU
 COLUMN_NUMBER  = 46
```

```
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = E11.3
 START_BYTE             = 185
 BYTES          = 4
 DESCRIPTION = "SBEU +5V current monitor (A)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = POS_12V_CURR_1_SBEU
 COLUMN_NUMBER  = 47
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = E11.3
 START_BYTE             = 189
 BYTES          = 4
 DESCRIPTION = "SBEU +12V current monitor #1 (A)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = POS_12V_CURR_2_SBEU
 COLUMN_NUMBER  = 48
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = E11.3
 START_BYTE             = 193
 BYTES          = 4
 DESCRIPTION = "SBEU +12V current monitor #2 (A)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = NEG_12V_CURR_SBEU
 COLUMN_NUMBER  = 49
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = E11.3
 START_BYTE             = 197
 BYTES          = 4
 DESCRIPTION = "SBEU -12V current monitor (A)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = MM_GUNN_CURR
 COLUMN_NUMBER  = 50
 DATA_TYPE              = IEEE_REAL
 FORMAT                 = F6.2
 START_BYTE             = 201
 BYTES          = 4
 DESCRIPTION = "mm LO Gunn current (mA)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = SMM_Mult_CURR
 COLUMN_NUMBER  = 51
 DATA_TYPE              = IEEE_REAL
```

```
 FORMAT            = E11.3
 START_BYTE        = 205
 BYTES       = 4
 DESCRIPTION = "smm multiplier current (mA)"
END_OBJECT         = COLUMN

OBJECT             = COLUMN
 NAME              = SMM_PLL_ERR
 COLUMN_NUMBER  = 52
 DATA_TYPE         = IEEE_REAL
 FORMAT            = F5.3
 START_BYTE        = 209
 BYTES       = 4
 DESCRIPTION = "static phase error for smm PLL (V)"
END_OBJECT         = COLUMN

OBJECT              = COLUMN
 NAME               = FS1_ERR
 COLUMN_NUMBER  = 53
 DATA_TYPE         = IEEE_REAL
 FORMAT            = F5.3
 START_BYTE        = 213
 BYTES       = 4
 DESCRIPTION = "Phase error for frequency synthesizer #1 (V)"
END_OBJECT         = COLUMN

OBJECT              = COLUMN
 NAME               = FS2_ERR
 COLUMN_NUMBER  = 54
 DATA_TYPE         = IEEE_REAL
 FORMAT            = F5.3
 START_BYTE        = 217
 BYTES       = 4
 DESCRIPTION = "Phase error for frequency synthesizer #2 (V)"
END_OBJECT         = COLUMN

OBJECT              = COLUMN
 NAME               = FS3_ERR
 COLUMN_NUMBER  = 55
 DATA_TYPE         = IEEE_REAL
 FORMAT            = F5.3
 START_BYTE        = 221
 BYTES       = 4
 DESCRIPTION = "Phase error for frequency synthesizer #3 (V)"
END_OBJECT         = COLUMN

OBJECT             = COLUMN
 NAME              = SMM_PLL_GUNN_CURR
 COLUMN_NUMBER  = 56
 DATA_TYPE         = IEEE_REAL
 FORMAT            = F6.2
```

```
 START_BYTE          = 225
 BYTES          = 4
 DESCRIPTION = "smm Gunn oscillator current (via PLL) (mA)"
END_OBJECT           = COLUMN

OBJECT               = COLUMN
 NAME                = SMM_PLL_IF_PWR
 COLUMN_NUMBER  = 57
 DATA_TYPE           = IEEE_REAL
 FORMAT             = E11.3
 START_BYTE          = 229
 BYTES          = 4
 DESCRIPTION = "smm PLL IF power monitor (V)"
END_OBJECT           = COLUMN

OBJECT               = COLUMN
 NAME                = SMM_GDO_VOLTAGE
 COLUMN_NUMBER  = 58
 DATA_TYPE           = IEEE_REAL
 FORMAT             = E11.3
 START_BYTE          = 233
 BYTES          = 4
 DESCRIPTION = "smm GDO bias voltage (V)"
END_OBJECT           = COLUMN

OBJECT               = COLUMN
 NAME                = SPAREF
 COLUMN_NUMBER  = 59
 DATA_TYPE           = IEEE_REAL
 FORMAT             = E11.3
 START_BYTE          = 237
 BYTES          = 4
 DESCRIPTION = "spare"
END_OBJECT           = COLUMN

OBJECT               = COLUMN
 NAME                = MIRPOS
 COLUMN_NUMBER  = 60
 DATA_TYPE           = MSB_UNSIGNED_INTEGER
 FORMAT             = I1
 START_BYTE          = 241
 BYTES          = 1
 DESCRIPTION = "Mirror position: 1: sky, 2: warm load, 3: cold load"
END_OBJECT           = COLUMN

OBJECT               = COLUMN
 NAME                = POWERMODE
 COLUMN_NUMBER  = 61
 DATA_TYPE           = MSB_UNSIGNED_INTEGER
 FORMAT             = I1
 START_BYTE          = 242
```

```
 BYTES          = 1
 DESCRIPTION = "Values 1-6 as described in MIRO User Manual 6.1.2.1.5"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = SUCR0
 COLUMN_NUMBER  = 62
 DATA_TYPE              = CHARACTER
 FORMAT                 = A2
 START_BYTE             = 243
 BYTES          = 2
 DESCRIPTION = "Low order bits 0-15 of Sensor Unit Control Register"

 OBJECT                 = BIT_COLUMN
  NAME                  = HSKMUX
  START_BIT             = 1
  BITS                  = 5
  BIT_DATA_TYPE         = MSB_UNSIGNED_INTEGER
  FORMAT                = Z5
  DESCRIPTION           = "Selects housekeeping channel"
 END_OBJECT             = BIT_COLUMN

 OBJECT                 = BIT_COLUMN
  NAME                  = NON5VSMM
  START_BIT             = 6
  BITS                  = 1
  BIT_DATA_TYPE         = MSB_UNSIGNED_INTEGER
  FORMAT                = Z1
  DESCRIPTION           = "Commands +5V, +/-12V on after -5V is commanded using smm cont mode"
 END_OBJECT             = BIT_COLUMN

 OBJECT                 = BIT_COLUMN
  NAME                  = IFPCTL0
  START_BIT             = 7
  BITS                  = 1
  BIT_DATA_TYPE         = MSB_UNSIGNED_INTEGER
  FORMAT                = Z1
  DESCRIPTION           = "Bit 0 of 4 bit ifp power control setting"
 END_OBJECT             = BIT_COLUMN

 OBJECT                 = BIT_COLUMN
  NAME                  = IFPCTL1
  START_BIT             = 8
  BITS                  = 1
  BIT_DATA_TYPE         = MSB_UNSIGNED_INTEGER
  FORMAT                = Z1
  DESCRIPTION           = "Bit 1 of 4 bit ifp power control setting"
 END_OBJECT             = BIT_COLUMN

 OBJECT                 = BIT_COLUMN
  NAME                  = MMLNAON
```

```
 START_BIT          = 9
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Powers on mm LNA bias 0 = on, 1 = off"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = SMMLNAON
 START_BIT          = 10
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Powers on smm LNA bias 0 = on, 1 = off"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = NON5VMM
 START_BIT          = 11
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Commands +5V, +/-12V on after -5V is commanded using mm cont mode"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = NON5VSPC
 START_BIT          = 12
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Commands +5V, +/-12V on after -5V is commanded using cts mode"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = PLLRESET
 START_BIT          = 13
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Phase-lock reset (0 locks, 1 unlocks) CF User Manual V6.2-7"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = IFPCTL2
 START_BIT          = 14
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Bit 2 of 4 bit ifp power control setting"
END_OBJECT          = BIT_COLUMN
```

```
 OBJECT                = BIT_COLUMN
  NAME                 = IFPCTL3
  START_BIT            = 15
  BITS                 = 1
  BIT_DATA_TYPE        = MSB_UNSIGNED_INTEGER
  FORMAT               = Z1
  DESCRIPTION          = "Bit 3 of 4 bit ifp power control setting (MSB)"
 END_OBJECT            = BIT_COLUMN

END_OBJECT   = COLUMN

OBJECT                 = COLUMN
 NAME                  = SUCR16
 COLUMN_NUMBER  = 63
 DATA_TYPE             = CHARACTER
 FORMAT                = A2
 START_BYTE            = 244
 BYTES          = 2
 DESCRIPTION = "High order bits 16-31 of Sensor Unit Control Register"
END_OBJECT             = COLUMN

 OBJECT                = BIT_COLUMN
  NAME                 = SMMGUNNOSCV
  START_BIT            = 1
  BITS                 = 4
  BIT_DATA_TYPE        = MSB_UNSIGNED_INTEGER
  FORMAT               = Z4
  DESCRIPTION          = "Setting for voltage to smm Gunn oscillator"
 END_OBJECT            = BIT_COLUMN

 OBJECT                = BIT_COLUMN
  NAME                 = MMGUNNOSCV
  START_BIT            = 5
  BITS                 = 4
  BIT_DATA_TYPE        = MSB_UNSIGNED_INTEGER
  FORMAT               = Z4
  DESCRIPTION          = "Setting for voltage to mm Gunn oscillator"
 END_OBJECT            = BIT_COLUMN

 OBJECT                = BIT_COLUMN
  NAME                 = NEG5VSMM
  START_BIT            = 9
  BITS                 = 1
  BIT_DATA_TYPE        = MSB_UNSIGNED_INTEGER
  FORMAT               = Z1
  DESCRIPTION          = "Set -5V for smm continuum mode"
 END_OBJECT            = BIT_COLUMN

 OBJECT                = BIT_COLUMN
  NAME                 = NEG5VMM
```

```
 START_BIT          = 10
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Set -5V for mm continuum mode"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = NEG5VCTS
 START_BIT          = 11
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Set -5V for cts mode"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = LDFRQ
 START_BIT          = 12
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Set and cleared to load the 3 frequency synthesizer chips""
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = MIRROROFF
 START_BIT          = 13
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "0: Mirror power on, 1: Mirror power off"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = MIRRORBACK
 START_BIT          = 14
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "1: backward mirror motion, 0: forward mirror motion"
END_OBJECT          = BIT_COLUMN

OBJECT              = BIT_COLUMN
 NAME               = SMMFRQSW
 START_BIT          = 15
 BITS               = 1
 BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
 FORMAT             = Z1
 DESCRIPTION        = "Set LO = 0 or 1 when frequency swtiching is on"
END_OBJECT          = BIT_COLUMN
```

```
  OBJECT              = BIT_COLUMN
   NAME               = PINPULLER
   START_BIT          = 16
   BITS               = 1
   BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
   FORMAT             = Z1
   DESCRIPTION        = "Set and cleared to activate mirror pin puller"
  END_OBJECT          = BIT_COLUMN

 END_OBJECT           = COLUMN

 OBJECT               = COLUMN
  NAME                = ADDR100
  COLUMN_NUMBER  = 64
  DATA_TYPE           = CHARACTER
  FORMAT              = A2
  START_BYTE          = 246
  BYTES        = 2
  DESCRIPTION = "Bits from address 100"

  OBJECT              = BIT_COLUMN
   NAME               = EMUX
   START_BIT          = 1
   BITS               = 5
   BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
   FORMAT             = Z5
   DESCRIPTION        = "Bits 0-5 set corresponding EMUX, 0-5"
  END_OBJECT          = BIT_COLUMN

  OBJECT              = BIT_COLUMN
   NAME               = SND2SU
   START_BIT          = 6
   BITS               = 1
   BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
   FORMAT             = Z1
   DESCRIPTION        = "Send command register data to Sensor Unit"
  END_OBJECT          = BIT_COLUMN

  OBJECT              = BIT_COLUMN
   NAME               = MOTSTEP
   START_BIT          = 7
   BITS               = 1
   BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
   FORMAT             = Z1
   DESCRIPTION        = "Enable motor stepping"
  END_OBJECT          = BIT_COLUMN

  OBJECT              = BIT_COLUMN
   NAME               = LDENABLE
   START_BIT          = 8
```

```
 BITS                = 1
 BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
 FORMAT              = Z1
 DESCRIPTION         = "1: Enable load, 0: Disable load""
END_OBJECT           = BIT_COLUMN

OBJECT               = BIT_COLUMN
 NAME                = POS12VSPEC
 START_BIT           = 9
 BITS                = 1
 BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
 FORMAT              = Z1
 DESCRIPTION         = "+12V Spectrometer on, 1: On, 0: Off"
END_OBJECT           = BIT_COLUMN

OBJECT               = BIT_COLUMN
 NAME                = POS5VSPEC
 START_BIT           = 10
 BITS                = 1
 BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
 FORMAT              = Z1
 DESCRIPTION         = "+5V Spectrometer on, 1: On, 0: Off"
END_OBJECT           = BIT_COLUMN

OBJECT               = BIT_COLUMN
 NAME                = POS5VANA
 START_BIT           = 11
 BITS                = 1
 BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
 FORMAT              = Z1
 DESCRIPTION         = "+5V Analog spectrometer on, 1: On, 0: Off"
END_OBJECT           = BIT_COLUMN

OBJECT               = BIT_COLUMN
 NAME                = POS3VSPEC
 START_BIT           = 12
 BITS                = 1
 BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
 FORMAT              = Z1
 DESCRIPTION         = "+3V Spectrometer on, 1: On, 0: Off"
END_OBJECT           = BIT_COLUMN

OBJECT               = BIT_COLUMN
 NAME                = NEG12VSPEC
 START_BIT           = 13
 BITS                = 1
 BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
 FORMAT              = Z1
 DESCRIPTION         = "-12V Spectrometer on, 1: On, 0: Off"
END_OBJECT           = BIT_COLUMN
```

```
 OBJECT                = BIT_COLUMN
  NAME                 = USO24V
  START_BIT            = 14
  BITS                 = 1
  BIT_DATA_TYPE        = MSB_UNSIGNED_INTEGER
  FORMAT               = Z1
  DESCRIPTION          = "+24V USO on, 1: On, 0: Off"
 END_OBJECT            = BIT_COLUMN

 OBJECT                = BIT_COLUMN
  NAME                 = CALHTRON
  START_BIT            = 15
  BITS                 = 1
  BIT_DATA_TYPE        = MSB_UNSIGNED_INTEGER
  FORMAT               = Z1
  DESCRIPTION          = "Calibration Heater On, 0: Off, 1: On"
 END_OBJECT            = BIT_COLUMN

 OBJECT                = BIT_COLUMN
  NAME                 = CTSTRISTORE
  START_BIT            = 16
  BITS                 = 1
  BIT_DATA_TYPE        = MSB_UNSIGNED_INTEGER
  FORMAT               = Z1
  DESCRIPTION          = "CTS Tri-state, 1: disable, 0: enable"
 END_OBJECT            = BIT_COLUMN

END_OBJECT             = COLUMN
```

The following is an example of the first record of an Engineering file, with just the first 4 of the 58 engineering data fields shown, in both hex and formatted representations:

```
Listing of rows     1 to     2 for file RO-CAL-MIRO-2-GRND-THERMALVAC-
V1.0/DATA/ENGINEERING/MIRO_2_HSK_20011410000.DAT

 COL.#:          1              2         3         4         5     60 61   62   63   64
 ITEMS:  41CD8476E0294984 C19DCEA5 41C03E77 41BF872B 41C042C4 01 06 0000 1004 0000
 ITEMS:  41CD8476E5C2F683 41C00553 41C08312 41BFCC30 41C042C4 01 06 001F 1004 0000

Listing of rows     1 to     2 for file RO-CAL-MIRO-2-GRND-THERMALVAC-
V1.0/DATA/ENGINEERING/MIRO_2_HSK_20011410000.DAT

 COL.#:          1               2          3          4          5      60  61    62    63    64
 ITEMS:   9.904408963E+08 -1.973E+01 2.403E+01 2.394E+01 2.403E+01   1   6     0  4100     0
```

7. Appendix 3: Available Software to read PDS files

The MIRO data files can be read by PDS-supported software such as NASAVIEW. Currently, the software used by the MIRO team to process the data files is code written by individual team members in IDL. PDS discourages the archiving of software, since it is generally difficult to maintain and port as available hardware evolves. Furthermore, IDL is a proprietary product. A simple Fortran-77 program to read and print out selected parts of the MIRO data files is included in the DOCUMENT directory, named MIRO_READ_DATA (see Section 3.4.3.7). It is described in Section 4.4.

It should be emphasised that program MIRO_READ_DATA is intended only as supplementary documentation and an example for understanding the structure of MIRO data. A more useful tool for processing MIRO data is an IDL package provided by PDS, named READPDS; for this, see:

http://pdssbn.astro.umd.edu/nodehtml/software.shtml

Here is an example of the use of READPDS to ingest a CTS file such as MIRO_3_CTS_20051792320.DAT in the Level-3 Deep-Impact archive.

To start, the following command should be issued:

```
IDL> data = readpds('MIRO_3_CTS_20051792320.LBL')
```

which will read the entire file into an object named "data.table". The structure of this object can then be viewed with the command:

```
IDL> help, /STRUCTURE, data.table
```

which shows that it contains 19 columns, named ".column1" through ".column19", with properties as defined in the .FMT files in this archive. In particular, the spectroscopic data themselves are accessible in the 2-dimensional object data.table.column19[4250,17112]. These can then be processed or plotted using standard IDL commands.